Droplet Cooling of Heated Surfaces: Experimental and Numerical Analysis

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Abstract

The present work is focused on measuring the transient contact temperature between a droplet and a hot solid surface. Experimental tests have been carried out employing infrared thermography. Droplets of bidistilled and deionized water have been gently deposited by a precision syringe onto the upper surface of a heated disk. This latter consists of a Barium Fluoride (BaF_2) disk, having high transmittance (about 90%) in the 8-12 μm range (typical of long-wave infrared cameras). The interface temperature has been measured from below through the solid material by an infrared thermocamera. As far as the solid can be assumed as infrared-transparent, a black coating layer has been applied to allow radiative heating of the solid surface. The bottom surface temperature of the coating is undistinguishable from the solid-liquid interface temperature and has been monitored. Single-phase evaporation regime has been analyzed in detail. A numerical code is then presented, which simulates evaporation process of water droplets on hot solid surfaces. The three-dimensional energy-diffusion equation is discretized by the finite volume method and is employed to model the transient temperature within both the droplet and the solid substrate. In this stage of development, the code simulates the substrate cooling effect due to a droplet in single-phase evaporation regime; however, its applicability to nucleate boiling and film boiling regimes can be considered as reasonably possible. The code is implemented in Matlab®, using a modular and flexible architecture. As a final task, numerical results are validated through a comparison with the experimental data.

Key words: droplet cooling; heat transfer; infrared thermography, numerical model.

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